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# Effects of pre-harvest foliar calcium sprays on fruit calcium levels and brown rot of peaches

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**Abstract**

Brown rot of stonefruits caused by *Monilinia fructicola* (Wint.) Honey continues to be responsible for significant crop losses in New Zealand despite the application of recommended fungicides. The goal of our research programme is to substantially improve brown rot management and in the first part of a multi-year programme, we investigated the hypothesis that supplementing a brown rot fungicide spray programme with calcium (Ca) reduces brown rot incidence. A range of commercially available Ca products were applied to peach (*Prunus domestica* L.) trees (cv. 'Scarlett O'Hara') at two weekly intervals from 3–5 November until fruit harvest (January 2001 and 2002) in the Hawke's Bay region of New Zealand. Calcium content of the peach epidermis was significantly increased by at least 50% by Ca sprays, compared to unsprayed fruit in both seasons. Increasing the Ca content of fruit significantly reduced the incidence and severity of *M. fructicola* infections in fruit disk assays. Pre-harvest Ca applications also significantly reduced the number of brown rot infected fruit per tree at harvest and the incidence of postharvest rots. The integration of Ca foliar sprays into current brown rot management practices has been widely adopted by stone fruit growers in New Zealand as a practical tool to reduce brown rot losses.


*Keywords:* *Monilinia fructicola*; Calcium; Integrated disease management; Disease control; Holistic approach; Stone fruit

## 1. Introduction

Calcium is an important constituent of plant tissues and has a vital role in maintaining and modulating various cell functions (Conway, 1982; Conway and Sams, 1987; Elad and Kirshner, 1992). Physiologically, it is important in many fruits and vines since it is associated with reduced senescence and retardation of softening in fruits (Ferguson, 1984; Gerasopoulos and Drogoudi, 2005), increased resistance to disease (Volpin and Elad, 1991) and abiotic stresses (Yuen, 1993). In contrast, calcium deficiency has been associated with postharvest fruit quality disorders, including surface pits and cracking in cherries (Brown et al., 1995) and increased susceptibility to fungal pathogens (Schwab et al., 1993).

The effect of calcium on enhancing postharvest fruit quality is well known (Raese et al., 1999), and there is also evidence to suggest that increased concentration of calcium in the fruit skin and flesh can reduce infection by fungal pathogens. Many studies report reduced incidence of *Botrytis cinerea* after pre- or postharvest application of calcium (Elad, 1997) to a range of fruit crops including red raspberries (Montealegre and Valdes, 1993), strawberries (Cheour et al., 1990; Pennisi et al., 2002), apples (Conway et al., 1994), grapes (Chardonnet et al., 1997) and sweet cherries (Demirsoy and Bilgener, 1998; Ippolito et al., 2005). In contrast, there have been relatively few reports on the effects of calcium on infection of stone fruits by *Monilinia* species, and some research findings have been inconsistent. Calcium applications reduced brown rot infections caused by *Monilinia* spp. in field tests (Adaskaveg et al., 1992; Børve et al., 2000) and in detached fruit experiments (Biggs et al., 1997). Calcium in the form of nitrate reduced the incidence of brown rot in two of the three years, and increased fruit Ca concentration in all three years, but both chloride forms had no effect on brown rot incidence or fruit Ca content (Wojcik, 2001).

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This indicates that the form of calcium is also potentially important for Ca uptake and disease suppression. Applications of calcium chloride did not reduce postharvest brown rot in peaches (Conway, 1987) or nectarines (Crisosto et al., 1997).

In seasons favourable for *Monilinia fructicola*, fruit losses in excess of 50% occur in New Zealand orchards (Elmer and Wood, unpublished data). Losses of this magnitude have occurred regularly over the last decade, despite applications of fungicides at the recommended phenological stages of fruit development. The introduction of new fungicide chemistry (e.g. the demethylation inhibitors), has contributed to improved brown rot control in some, but not all orchards, and effective long-term management has not been realised. We critically reviewed brown rot suppression practices in New Zealand recently and recommended that a more holistic approach be adopted: with greater emphasis on inoculum removal, improved timing of fungicide (based on new epidemiological knowledge), enhanced host nutrition to reduce fruit susceptibility, reduced nitrogen inputs, greater use of biological control agents and elicitors of host defence, and predictive tools to aid pre-harvest and postharvest decision making (Spiers et al., 2005). Greater emphasis on non-chemical strategies has the additional advantage of extending the effective commercial life of current fungicides and reducing the risk of resistance development (Elmer and Gaunt, 1993).

In this study we report on the first step towards a fully integrated brown rot management system for peaches by examining the effects of foliar calcium applications on fruit Ca content and on brown rot control.

## 2. Materials and methods

### 2.1. Trial description

In the 2000/01 season five commercial calcium foliar sprays (Table 1) were applied to three year old peach (cv. 'Scarlett O'Hara') trees in a research orchard in Hawke's Bay, on the East coast of the North Island of New Zealand. In these studies we focused on the chloride form of soluble calcium, since the nitrate form has the potential to encourage more vigorous shoot growth and divert xylem calcium away from fruit. Application rates used were those recommended on the label or by the manufacturer. A control (unsprayed) treatment was included, and there were six single-tree replicates in a randomised block design. The block comprised three rows with 12 trees (two replicates) in each row. The treatments were applied at half strength for the first three applications to avoid damage to the small fruit (length = approximately 15 mm), starting on 3 November 2000, then every two weeks until 12 January 2001, a total of six sprays. Treatments were applied to the whole tree to run-off, at a rate of 1.4 l/tree, equivalent to 1000 l/hectare. The trees were otherwise

Table 1
Calcium foliar spray products, Ca content and form, distributors' recommended rates, total Ca applied per tree and resulting Ca concentration in the epidermis of peaches (cv. 'Scarlett O'Hara') at harvest in 2000/2001 and 2001/2002

| Season | Product[a] | Ca content (%) | Ca form | Application rates ml 10 l$^{-1}$ | | Total Ca applied g/tree | Ca concentration mg 100 g$^{-1}$ dry weight |
|---|---|---|---|---|---|---|---|
| | | | | Early | Late[b] | | |
| 2000/2001 | A | 16 | Chloride | 50 | 100 | 10.1 | 78 |
| | B1 | 15 | [c] | 25 | 50 | 4.7 | 65 |
| | C | 15 | Chloride[d] | 25 | 50 | 4.7 | 61 |
| | D1 | 17.5 | Chloride | 50 | 100 | 10.7 | 78 |
| | E | 17 | Nitrate[e] | 45 | 90 | 9.6 | 77 |
| | Control | — | — | — | — | 0 | 59[f] |
| 2001/2002 | A | 16 | Chloride | 50 | 100 | 10.1 | 140 |
| | B2 | 15 | [c] | 50 | 100 | 9.5 | 90 |
| | D1 | 17.5 | Chloride | 50 | 100 | 10.7 | 90 |
| | D2 | 17.5 | Chloride | 100 | 100 | 14.3 | 90 |
| | D3 | 17.5 | Chloride | 0 | 150 | 10.7 | 90 |
| | D4 | 17.5 | Chloride | 50 | 150 | 14.3 | 100 |
| | D5 | 17.5 | Chloride | 100 | 150 | 17.9 | 100 |
| | F | 15 | Glycine chelate | 50 | 100 | 10.4 | 90 |
| | Control | — | — | — | — | 0 | 90[g] |

[a]Product codes: the letter represents the product applied, the number represents the rate used.
[b]Stated on product label or recommended by manufacturer or distributor.
[c]Not stated.
[d]Also contains 50 mg/kg manganese and 50 mg/kg zinc.
[e]12.1% nitrate, 4.9% chloride; also contains 4% magnesium and 1% boron.
[f]Least significant difference ($P = 0.05$) for 2000/2001 season was 11.5.
[g]Replicates bulked, so statistical analysis was not possible for 20001/2002 season.